

WHAT IS CLAIMED IS:

1 1. A method of detecting the presence of mixed venous and arterial blood
2 pulsation in tissue, comprising:

3 receiving first and second electromagnetic radiation signals from a blood
4 perfused tissue portion corresponding to infrared and red wavelengths of light;
5 obtaining a measure of a phase difference between said first and second
6 electromagnetic radiation signals;
7 comparing said measure with a threshold value to form a comparison; and
8 detecting the presence or absence of venous pulsation using said comparison.

1 2. The method of claim 1 further comprising filtering said first and
2 second electromagnetic radiation signals before said obtaining said measure, to pass portions
3 of said first and second electromagnetic radiation signals having frequencies at or near the
4 pulse rate or harmonics of the pulse rate of said blood perfused tissue.

1 3. The method of claim 1 wherein said obtaining a measure of a phase
2 difference between said first and second electromagnetic radiation signals comprises
3 obtaining a measure of a persistent phase difference between said first and second
4 electromagnetic radiation signals.

1 4. The method of claim 3 wherein said obtaining a measure of a persistent
2 phase difference comprises integrating said measure of a phase difference over a time period.

1 5. The method of claim 1 wherein said obtaining a measure of a phase
2 difference comprises obtaining a measure of the openness of an ellipse on a Lissajous plot
3 formed by comparing the first electromagnetic radiation signal against the second
4 electromagnetic radiation signal.

1 6. The method of claim 1 wherein said obtaining a measure of a phase
2 difference comprises analyzing a cross-correlation function of said first and second
3 electromagnetic radiation signals, as a function of a delay interval between them.

1 7. The method of claim 1 wherein said obtaining a measure of a phase
2 difference comprises a frequency domain analysis and subtracting the phases of said first and
3 second electromagnetic radiation signals at a frequency.

1 8. The method of claim 7 wherein said subtracting the phases of said first
2 and second electromagnetic radiation signals comprises taking the complex conjugate of said
3 first and second electromagnetic radiation signals, and dividing said complex conjugate by
4 the product of the magnitudes of said first and second electromagnetic radiation signals.

1 9. The method of claim 1 wherein said obtaining a measure of a phase
2 difference comprises obtaining said measure of a phase difference at or near a fundamental
3 pulse rate of said blood perfused tissue.

1 10. The method of claim 1 wherein said obtaining a measure of a phase
2 difference comprises obtaining said measure of a phase difference at or near a harmonic of a
3 pulse rate of said blood perfused tissue.

1 11. The method of claim 1 wherein said obtaining a measure of a phase
2 difference comprises obtaining said measure of a phase difference at or near a fundamental or
3 at or near a harmonic of a pulse rate of said blood perfused tissue.

1 12. The method of claim 1 further comprising providing a notification of
2 the presence of venous pulsation.

1 13. A device for detecting the presence of mixed venous and arterial blood
2 pulsation in tissue, comprising:

3 means for receiving first and second electromagnetic radiation signals from a
4 blood perfused tissue portion corresponding to infrared and red wavelengths of light;

5 means for obtaining a measure of a phase difference between said first and
6 second electromagnetic radiation signals;

7 means for comparing said measure with a threshold value to form a
8 comparison; and

9 means for detecting the presence or absence of venous pulsation using said
10 comparison.

1 14. The device of claim 13 further comprising a filter configured for
2 filtering said first and second electromagnetic radiation signals before obtaining said
3 measure, to pass portions of said first and second electromagnetic radiation signals having

4 frequencies at or near the pulse rate or harmonics of the pulse rate of said blood perfused
5 tissue.

1 15. The device of claim 13 wherein said means for obtaining a measure of
2 a phase difference between said first and second electromagnetic radiation signals are
3 configured for obtaining a measure of a persistent phase difference between said first and
4 second electromagnetic radiation signals.

.1 16. The device of claim 15 wherein said means for obtaining a measure of
2 a persistent phase difference comprises means for integrating said measure of a phase
3 difference over a time period.

1 17. The device of claim 13 wherein said means for obtaining a measure of
2 a phase difference is configured for obtaining a measure of the openness of an ellipse on a
3 Lissajous plot formed by comparing the first electromagnetic radiation signal against the
4 second electromagnetic radiation signal.

1 18. The device of claim 13 wherein said means for obtaining a measure of
2 a phase difference is configured for analyzing a cross-correlation function of said first and
3 second electromagnetic radiation signals, as a function of a delay interval between them.

1 19. The device of claim 13 wherein said means for obtaining a measure of
2 a phase difference is configured for a frequency domain analysis and for subtracting the
3 phases of said first and second electromagnetic radiation signals at a frequency.

1 20. The device of claim 19 wherein said means for subtracting the phases
2 of said first and second electromagnetic radiation signals is configured for taking the complex
3 conjugate of said first and second electromagnetic radiation signals, and dividing said
4 complex conjugate by the product of the magnitudes of said first and second electromagnetic
5 radiation signals.

1 21. The device of claim 13 wherein said means for obtaining a measure of
2 a phase difference is configured for obtaining said measure of a phase difference at or near a
3 fundamental or at or near a harmonic of a pulse rate of said blood perfused tissue.

1 22. The device of claim 13 further comprising means for providing a
2 notification of the presence of venous pulsation.